DETAIL DESIGN DESCRIPTION

CHAPTER 6
POWER INTAKE

[UPPER TRISHULI-1 HEP (216MW)]

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DOOSAN Enerbility

FOR INFORMATION

0	2022.12.30	Dong Z.Z.	Zhang Jiqiang	Li Weigong	For Information
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Upper Trishuli-1 HEP (216MW)

Owner

NWEDC
NEPAL WATER AND ENERGY DEVELOPMENT CO. PVT.LTD.

Owner's Engineer

TRACTEBEL ENGIE

jade CONSULT

Contractor

DOOSAN Enerbility

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6 Power Intake

6.1 General

Generally speaking, intake is a civil structure to supply water for power generation to powerhouse. When water flows into the intake, sediment particles and floating debris should be excluded, and it should be designed for easy O&M as well as economical efficiencies. The shape of the structure should be designed to take the design discharge for power generation in consideration of the hydraulic aspects such as a uniform distribution of a flow velocity and prevention of vortex formation.

6.2 Design Criteria

As per Contract Document ANNEX 13 EMPLOYER'S REQUIREMENT, Annex 13 Part B Design Requirement (1. Main Body), 13-B1-2.4.2 Intake:

A. The Intake shall be designed for the design discharge for power generation ($76m^3/s$)

B. A gravel trap is provided immediately upstream of the Intake gate. Flushing of the gravel trap shall be by manual control of the gravel gates.

C. During drawing water through the intake, neither harmful hydraulic phenomenon such as vortex nor harmful vibration at the trashrack(s) shall be allowed.

D. The maximum net flow velocity in intake shall be less than about 1m/s. The form and arrangement of the intake structure shall be designed to satisfy this requirement and shall incorporate gradual hydraulic efficient transitions to minimise head losses.

E. Inundation of Intake gate hoist and flowing of water into the air hole due to flood shall be avoided.

F. The deck level of the intake structure shall provide adequate access and working area for cleaning and maintaining the trash racks. The trashracks shall extend to the deck level. The deck shall be provided with a minimum freeboard of 1.8m during the design flood.

G. The trashracks shall be cleaned by a trash rake Cleaner.

H. To protect the excavated riverbed and adjacent area for the intake from erosion to be caused by river flow, appropriate protection work for the bank slopes and riverbed is required.

I. Suitable permanent slope protection works shall be provided at the excavated area considering Nepal Practice .

6.3 Types

There are two kinds of intakes; vertical morning glory and horizontal bell-mouth type. The UT-1 plant is planned to be located in a narrow gully in which vertical morning glory type is not more favourable than horizontal bell-mouth type. Therefore, horizontal bell-mouth type with easier O&M has been selected. The type of intake is shown in <Table 6.3-1>.

Table 6.3-1 Intakes types

Items	Vertical morning glory type	Horizontal bell-mouth type
Pros & Cons	· Difficulties in gate installations and expensive installation cost. · For an equal flow distribution of the inflow amount into the intake, a large area is required near the intake · The length of the channel became longer than the horizontal bell-mouth type	· Simple gate installation · Easy O&M · Decrease of approach velocity at the intake trashrack · Large area not required except the front of the intake · The channel length is shorter than the vertical morning glory type.
Result		
Remarks	· O&M of the horizontal bell-mouth type is easier than the vertical morning glory type. Excavation volume will be smaller as spacious area infront of the intake is not required. Thus, the horizontal bell-mouth type has been selected for simple construction.	

6.4 Location

The intake is a concrete structure of which height is over 25 m. In general, the intake structure should be placed on fresh hard rock with enough bearing capacity, and its location should be selected to ensure enough space for excavation & building equipment.

The currently planned intake is located near the right abutment of the weir on the plan view. Generally, the location of the intake should be spaced out from the weir due to floating debris caused by the weir. But in order to minimize the sediment inflow, the location close to the spillway has been selected and floating debris near the weir could be frequently treated by installing the overflow spillway at the right abutment of the weir.

6.5 Gate and stoplog

The intake gate is installed for maintenance of the waterway tunnel during plant operation. The intake gate is always submerged except for the time when O&M works are carried out. Thus, opening and closing of the intake by a crane at the gate tower has been designed regardless of water levels during gate installation and operation. Also, a stoplog has been designed for maintenance of the roller gate and tranquilizing basin at the portal of the intake.

The gate elevation has been reviewed to avoid defects caused by the reservoir water level rising during inspection of the waterway tunnel and O&M works. Thus, the top elevation has been set at

El. 1259.0 m, which is the same as the dam crest considering an abnormal flood, which might overtop the upper structure of the intake. Furthermore, a road for O&M with a width of 5.0 m has been planned to allow access from the dam crest to the upper structure of the intake.

6.6 Approach velocity

As the approach velocity at the intake gets slower, hydraulic flow performance tends to be better. It is recommended by ASCE that velocity in a structure with trashrack installed should be 0.6 ~ 1.5m/sec. Therefore, the intake size has been designed to allow inflow of 86.8(Including for plant discharge and gravel trap pipe discharge) m^3/sec. In order to prevent the inlet loss and trashrack vibration, the cross section has been designed that the approach velocity should be less than 1.0m/s, which is the average value of the approach velocity suggested by ASCE.

The presently planned intake structure is to install a bar screen, which is for preventing a big size of debris from flowing into the intake portal. Also, a tranquilizing basin has been installed to gather bed loads and a trash rack with traveling rake cleaner has been designed. The area of the bar screen is 84.5 m^2(W 6.5 m × H 6.5 m × 2 Nos, Q=86.8 m^3/sec) and inflow velocity, 1.028 m/sec, is satisfied with the criteria ASCE. Also, the velocity will become slow due to tranquilizing basin section and the velocity, 0.73 m/sec at the trash rack, which has an area of 104 m^2 (W 6.5 m × H 8.0 m × 2 Nos, Q=76.0 m^3/sec), is also satisfied with the standard.

6.7 Submergence depth

Enough submergence depth is necessary to prevent a vortex occurence causing the air entrainment that will affect the generation also a damage to the turbine. The formula from the Civil Engineering Guidelines for Planning and Designing, Hydroelectric developments, Volume 2, Waterways (ASCE, 1989) was used for a calculation of adequate submergence depth.

Currently planned intake is short of the standard for the submergence depth because of the intake tunnel change to a vertical alignment for the following reasons.

○ The disadvantage of the construct ability caused by the curve shape of originally planned intake tunnel inlet part.

○ Secure stability at the intersection between the intake tunnel and the diversion tunnel.

However, because the intake tunnel(approx.340m) is connected to the desander where is an open channel, the slight influence by the lack of submergence depth will be influence on the intake tunnel only. Therefore, it has reviewed the submergence depth at the connecting point of the headrace tunnel after the desander according to the above ASCE standard. The calculation formula for review is as follow.

$$S = C \times F \times D = 1.7 \times 0.38 \times 3.74 = 2.42 \text{ m}$$

Where,

S : Submergence (m) required to prevent vortex problem

C : Empirical coefficient (1.7)

D : Tunnel diameter (3.74 m)

F_r : Frude number ($\frac{V}{\sqrt{gD}}$ = 0.38)

V : Average velocity ($\frac{4Q}{\pi D^2}$= 2.31 m/sec)

Q : Discharge (25.33 m^3/sec)

The calculated minimum submergence depth through the above calculation formula is 2.42m and the current submergence depth of planned section is about 9.0m (El.1,254.0m ~ El.1,245 m). There is approximately 6.58m margin. Hence, it is judged that there will be no problem related to the aeration by vortex.

6.8 Process of the hydraulic model test for the intake

Please refer to hydraulic model test report.

6.9 Other structures

6.9.1 Gravel trap

6.9.1.1 Purpose

In the Trishuli River, a significant amount of sediment is transported downstream by flowing water. Sediment is divided into suspended load and bed load. For the UT-1 HEP project, a desander structure is installed to trap suspended load. With continuous river flow, a great amount of sediment piles up in front of the intake as time goes by, which causes inflow of bed load to the intake portal. Therefore, the measurement to prevent sediment inflow has been developed.

In the detail design of which performance has been verified, the tranquilizing basin is planned to gather the sediment by reducing the flow velocity. The bed load settled down in the tranquilizing basin is discharged into the flushing pipe(Carbon steel, D1.0m). The monthly average amount of sediment inflow to the reservoir is shown in <Table 6.9-1>.

Table 6.9-1 Expected inflow sediment amount (suspended + bed load (20% of suspended))

Type	Jan	Feb	Mar	Apr	May	Jun
Mean Discharge (m^3/sec)	43.7	38.6	38.6	49.5	87.5	230.4
Inflow sediment Amount(m^3)	3389.6	3942.2	6844.8	10194.9	68111.0	384537.3
Type	Jul	Aug	Sep	Oct	Nov	Dec
Mean Discharge (m^3/sec)	487.0	557.8	370.8	160.4	79.9	54.6
Inflow sediment Amount(m^3)	1940963.6	1521993.3	602059.4	96695.4	13539.9	7868.5

6.9.1.2 Location & Size

The size and location of tranquilizing basin and gravel trap flushing pipe are efficiently decided by hydraulic model test. Especially, since they have roles of flushing sediment and controlling environmental release, valves are planned to control the discharge of each pipe.

The layout for gravel trap and discharge according to gate opening are as shown in the following table.

Table 6.9-2 Summary of gravel pipe

Division	Description	Remarks
Type	Steel pipe, Circular shape	
Size	D 1.0 m, L 28~31m, 2EA	

6.9.2 Bed load sluice

This structure with the size of W 2.5m and H 2.5m has been planned to removal sediment or bed load in front of the intake. A sluice gate has been planned at the right abutment of the weir to control flow and sediment discharge in the reservoir. Also, the same sluice gate has been planned in front of the gate for the maintenance. The summary for bed load sluice and discharge according to bed load sluice gate opening are as shown in the following table.

Table 6.9-3 Summary of bed load sluice

Division	Description	Remarks
Sill elevation	EL.1239.5m	
Main gate	Slide gate (W 2.5 m x H 2.5 m, 1 unit)	
Gate for maintenance	Slide gate (W 2.5 m x H 2.5 m, 1 unit)	

Table 6.9-4 Discharge according to bed load sluice gate opening

Height of gate (m)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Discharge (m^3/sec)	3.11	6.20	9.10	11.94	14.86	17.54	20.13	22.85	25.40
Height of gate (m)	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Discharge (m^3/sec)	28.03	30.46	32.83	35.32	37.77	40.18	42.55	44.89	47.19
Height of	1.9	2.0	2.1	2.2	2.3	2.4	2.5		

gate (m)									
Discharge (m^3/sec)	49.46	51.68	53.87	56.03	58.14	60.22	62.27		

6.9.3 Rockfall protection measures at the slope of the intake portal

Rockfall protection facilities mean structures to prevent the damage of structures, and loss of property and life caused by rock falls or landslides on cut-slopes.

Rockfall protection measures consist of reinforcement method and protection method. The reinforcement method includes removing rock fragments in advance where rockfall is expected or fixing rock fragments to the cut-slopes. Protection method is installing structures on road facilities or roadside structures in order to prevent rock fragments from falling on the road. The types of rockfall protection measures are shown in <Table 6.9-5>.

Table 6.9-5 The types of rockfall protection measures

Methods	Types	Remarks
Reinforcement method	Resloping, Triming, Anchor, Rock Bolt, Buttresses, Concrete Crib, Shot-crete, Drainage(Surface drainage, Subsurface drainage)	
Protection method	Rockfall protection net, Rockfall protection fence, Rockfall protection barrier, Rock sheds, Vegetation	

The risk of rockfall has been minimized because reinforcement method such as shotcrete and wire mesh was applied to the slope of the intake portal in UT-1 HEP project. However, the additional rockfall protection method should be required, because the risk of small rockfall still exists.

6.9.3.1 Rockfall protection method

The currently planned intake portal area has many dangerous aspects from falling rocks due to broaden cut-slope by higher terrain. Especially, the mechanical facilities such as the hoist tower and trashrack cleaner are extremely vulnerable to falling rocks. Therefore, the rockfall protection for mechanical facility is designed on way to install a steel roof. In relation to the size and others of the steel roof, it will depend on the site conditions such as the frequency and scale of falling rocks on site.